LECTURE,

&c. &c.

A LECTURE

ON

THE FUNCTIONS

OF

THE LYMPHATIC SYSTEM.

BY

ROBERT JAMES GRAVES, M. D. M. R. I. A.

KING'S PROFESSOR OF THE INSTITUTES OF MEDICINE IN THE SCHOOL OF PHYSIC IN IRELAND.

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A LECTURE,

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Gentlemen,

In endeavouring to obtain a knowledge of the use and functions of the Lymphatic System, it is necessary, in the first instance, to compare the classes of animals which possess lymphatics, with those in which they are wanting, in order that we may obtain data to direct us in this important and difficult inquiry. In animals with brain and spinal marrow, including the four superior classes, Mammalia, Birds, amphibious Animals, and Fishes, we find a distinct system of vessels containing a comparatively colourless fluid, and termed lymphatics; in addition to which all these animals have arteries and veins for the circulation of red blood.

In animals without brain or spinal marrow, including Zoophytes, Mollusca, and Articulata, we do

not find two sets of vessels in which fluids circulate towards the heart; in these animals there is no such distinction between the vessels of the general circulation, and the system in the higher animals termed lymphatic; and whatever the office of the latter is, it is performed in the invertebrated animals by the veins of the general circulation. In other words, the functions of both veins and lymphatics are in these animals discharged by one set of vessels, which have been usually termed veins.

The division of the animal kingdom provided with a lymphatic system, is still further distinguished from that in which this system is wanting, by the red colour of the blood; and two of the higher orders are remarkable for its considerable warmth, while the inferior classes have a comparatively cold and colourless fluid, circulating, or at least moving within the sphere of their vascular system.

This great and marked distinction may therefore be made between vertebrated and invertebrated animals, that the vascular system of the former includes two parts, one containing red blood, circulating in arteries and veins; and the other, a transparent colourless fluid, conveyed towards the heart by the lymphatics, while the vascular system of the latter is single, being confined to vessels circulating a colourless fluid.

The solids of red-blooded, compared with those of white-blooded animals, present a difference corresponding to that of the fluids; for as the vascular system of the superior classes contains both red and

colourless fluids, so we find both red and white structures or tissues in the solid portions of their bodies. In the mammalia the muscles both of voluntary and involuntary motion, which constitute so great a part of the bulk of the body, belong to the red structures; among the white may be enumerated, the cellular, serous, synovial and fibrous membranes, ligaments, cartilages, the animal basis of bone, &c. In the invertebrated animals, on the contrary, the whole solid system belongs to the class of colourless tissues, or at least, includes nothing similar to the red solids of vertebrated animals.

Let us next consider, whether in the four superior classes the quantity of red blood is proportioned to the quantity of red solids.

In the *Mammalia* we have a large proportion of red blood, and a corresponding extent of developement in the red solids.

In *Birds*, we have a rapid circulation of very warm and highly coloured red blood, and a corresponding preponderance of the muscular system, which is also very dense and red, with the exception of muscles but little used, as the pectoral muscles of the Gallinæ.

In the *Amphibia*, the proportion of red blood, is small, when compared with that of the Mammalia and Birds, and accordingly the muscular system is proportionably paler, or in other words, the white parts predominate over the red, even in the muscular system. In some of the amphibia, however, as the Frog, the

proportion of red blood is greater, and the colour of the muscles higher.

In *Fishes* the proportion of red blood is still smaller, and the muscular fibre usually soft and colourless, and so sparingly supplied with red blood, that an extensive incision into the great lateral muscles is followed by but a slight effusion of blood.* In several fishes the muscles of the fins are of a redder colour, and more abundantly supplied with red blood; and in the Salmon they are of a bright red colour about the head, immediately below which the heart is placed.

It may therefore be looked on as established, that in animals provided with a vascular system, one part of which contains a red blood, and the other a colourless fluid: the quantity of red blood is proportioned to the *quantity of red tissues.*

Applying the same method of investigation to the quantity of white fluid contained within the vascular system, as compared with the proportion of white tissues, we observe that in proportion as the red blood and red parts diminish that of white fluid and white structures increase. Thus in the *mammalia*, although the lymphatic system is extensive, yet it does not at all bear the same relative proportion to the vascular system of red blood as in fishes; in which the investi-

* Carus' Comparative Anatomy.

gations of Fohman have shown a great preponderance of the lymphatic over the venous system.*

From these facts we are inevitably led to conclude:

1st. That the functions of the lymphatic system of red-blooded animals is intimately connected with the white structures or tissues of these animals.

2d. That a similar connexion exists between the red portions of the vascular system of these animals, and their red solids.

At this stage of the inquiry, the following questions naturally present themselves:—

1st. Whether, in their natural state, any red blood circulates in the white tissues?

2d. Whether a colourless fluid circulates in these parts?

To the first question we may confidently answer, that no red blood circulates in the white structures during health; for although it is possible that *red blood* might circulate in a single capillary, so small as to have no perceptible colour, yet no considerable number of such minute capillaries could exist in any

* Majendie has very erroneously denied the existence of lymphatics in amphibious animals and fishes. The testimony of Hewson and Monro has been fully confirmed by the investigations of *Fohman*, in the first number of his valuable work, *Das Saugadersystem der Wirbelthiere.*

structure, without producing collectively a perceptible red colour: for many white parts possess such density and bulk, that if they contained such minute red vessels, although the latter might appear white individually, yet they must appear red when viewed several together.

The second question is not so easy of solution. Some physiologists, with the celebrated Rudolphi at their head, have denied all proper vascularity to cellular, serous, fibrous, and other white structures; and maintain, that the fluids exhaled from the serous and cellular membrane are the products, not of any secretion from the vessels of the white parts themselves, but are derived from the structures in connexion with, or covered by, these white structures, and merely transude through the latter, in the same way that the sweat passes through the epidermis; and in a similar way they endeavour to account for the products of inflammation, that had been commonly considered as derived from the white structures.

Thus they attribute the exhalation of serous membranes in health, and their exudations in disease, to the vessels of the parts they cover, not to any vessels of their own, the existence of which they deny, on the ground of their being incapable of being injected.

The following reasons seem to me conclusive in proving, not only that the white tissues have a proper circulation of white blood, but also that they are capable of undergoing a twofold species of inflammation:—

1st. When we irritate a white part, it soon be

comes red, from the appearance of minute vessels carrying red blood. These vessels appear often so suddenly, that we are forced to admit their previous existence in the part; and the existence of vessels being thus proved, it follows that the fluid circulating in them must have been white, for otherwise they would have been visible. This simple experiment on the living animal enables us to prove the existence of minute vessels in white parts, conveying in health a white fluid, and directly continuous with the arteries, as is shown by the immediate entrance of arterial blood into these vessels, when the part is stimulated.*

2d. We find that the pseudomembranes so often formed between the pleura pulmonalis and pleura costalis, are capable of becoming vascular, red, and inflamed, and are sometimes found covered with an exudation of coagulable lymph.

It is quite evident that in such membranes, quite unconnected as they are with any red part, the vascularity observed during inflammation must belong to themselves. When the inflammation subsides, the vessels into which red blood had found its way, again convey a white fluid, and consequently become invisible.

3d. Where a serous membrane covers another white structure, in the manner that the synovial membranes are attached to the cartilages and capsular ligaments of joints; when we find, as is often the case, that the internal surface of the joint becomes highly

* See experiments by Hunter, in his Treatise on Inflammation. Also Thompson on Inflammation.

red and inflamed, we must attribute this morbid vascularity to one or other of the white structures, for in this case no other structure enters into the composition of the part.

4th. The synovial membranes furnish us also with conclusive evidence against the opinion, that the *serous exhalation* is not derived from, but is merely an exudation through the serous membrane, and that this exhalation is derived from some part furnished with red vessels, for the synovial membranes in health are covered by a copious exhalation, serving to lubricate the articular cavities; and which secretion cannot have been produced except by a white structure, as none other enters into the composition of the joint.

5th. The exhalation of cellular and serous membranes is closely allied in chemical composition to the serum of the blood, and is therefore probably derived directly from it, as it circulates in the white parts, and not indirectly from red blood circulating in red parts.

6th. That a circulation is carried on in the white parts, has been proved by the experiments of Mayer, who detected prussiate of potash in the tendons, ligaments, &c., in a few hours after he had injected a solution of this salt into the lungs of animals.

All these reasons seem conclusive in proving that the white tissues are, during health, provided with vessels continuous with the arteries, but conveying only the serous portions of the blood; and that in disease these vessels admit red blood, and thus these parts become the seat of red inflammation.

In the higher order of animals, as the mammalia, all the blood is sent from the heart through the arteries, to be distributed to all parts of the body. This blood consists of two portions; a red fibrinous portion, and a serous albuminous portion. The two portions together circulate through the arteries, and are returned by the veins, passing through parts of a red colour and fibrinous composition; while a part of the serum enters into the minute arterial branches, which, supplying the white parts, do not admit the red or fibrinous portion; and thus a serous or white blood is distributed to the white structures, whose albuminous secretions and albuminous basis agree so exactly with the composition of the fluid thus destined to support their nutrition and carry on their functions.

As a serous or white blood is conveyed from the heart to the white parts, it is evident that some means must be provided for its return towards the heart; and for this purpose, we find these parts plentifully supplied with lymphatics, vessels which discharge the office of conveying back the white blood from the white structures, and which may therefore be called the *veins of the white parts.*

They agree, indeed, with the veins of the red parts in several respects.

Both are provided with valves. In both, the contained fluid flows towards the heart, and is in both propelled in a constant equable current.

As the lymphatics return the white blood from the white structures of the body, their contents also require to be submitted to the aerating action of respi-

ration; and hence that portion of their fluid, which had not joined the red veins sooner, is emptied into them before they arrive at the heart.

A fact discovered by Fohman concerning the distribution of the lymphatics in fishes, is almost decisive on the point, of their being white veins; for he has found a considerable lymphatic trunk conveying lymph to be aerated in the gills, while another trunk conveys venous blood to be aerated in the same organ.

This fact evidently accords as much with the idea of the lymphatics conveying back white blood, to be renewed by respiration, and rendered again fit for the nutrition of the white parts, as it is irreconcileable with the commonly received opinion, of their containing the useless *debris* absorbed from the various organs.

Many objections, indeed, of great weight, have been urged against the opinion, that the lymphatics convey back the *debris* of all parts of the body, or, in other words, serve the purpose of removing by absorption all that has become useless in the different structures. The fluid they contain is too colourless to be the vehicle of coloured particles, and is too simple and uniform in its composition, to allow us to suppose it to be formed by the union of particles absorbed from structures so various as those of the body.

That the lymphatics perform the office of returning the white blood, (by white blood I mean not a fluid absolutely colourless, but a fluid destitute of the peculiar colour of red blood,) is further rendered proba-

ble by the fact, that when in disease red blood finds its way into the white capillary arteries of white parts, the lymphatics are found to carry red blood from the inflamed part,* and in suppuration purulent matter has been also found in the lymphatics.†

The nutrition of the red parts is accomplished by the constant circulation of red blood through them, that of the white parts, by the circulation of the serous portion of the blood; and to effect these two different purposes, a portion of the serum is separated in the smaller vessels. When, however, the red blood and the white blood have circulated through the red and the white parts, there is no longer any necessity for their being kept altogether distinct from each other; in the *mammalia* the *conglobate glands* in the first instance, serve to promote the reunion of the red and white blood, and the larger lymphatics, which open into the subclavian veins, finally complete the reunion of these two portions of the blood. In fishes, Fohman has pointed out numberless communications between the venous and lymphatic system almost at the roots of the latter.

* Mickel.

† Majendie, who relates that in a case dissected by Dupuytren, fluid, in its physical properties resembling pus, was found in the lymphatics coming from the part, endeavours, but I think on insufficient grounds, to make it appear that the fluid was not really purulent.

In his zeal to advocate the absorbing powers of the veins, he has also denied the facts reported by Cruikshank and others, of blood having been observed in the lymphatics, but it is evident, that as white parts are not provided with veins, the only channel through which the red blood that certainly finds its way into them during inflammation, can be returned towards the heart, is by the lymphatics.

The white structures of the higher animals resemble the solids of white-blooded animals, not only in health, but disease. Thus the power of *reproduction* of parts destroyed by accident or disease, so remarkable in the lower orders of animals, is in the higher engaged only by white structures, such as cellular membrane; for proper muscular fibre when once destroyed is not reproduced, condensed cellular membrane being employed to repair solutions of continuity, in this as well as all more highly organized tissues.

In white-blooded animals, we often see a new limb appear in the place of one destroyed by accident, and in man, it is not unfrequent to observe a *new white organ* produced, when the old has become useless, or been destroyed. Thus in unreduced dislocations, we have new bursæ mucosæ, capsular ligaments, synovial membranes, &c. produced so as to form almost all the appendages necessary either to the strength or motion of the new joint. The same happens in ununited fractures. Cartilage is thrown out to supply the place of bone removed by operation or disease, and under favourable circumstances this cartilage itself becomes ossified, and, as happens in Necrosis, an entirely new bone is sometimes produced. In all such cases the mould of the bone, or that part of it to which the new bone owes its form and bulk, is composed of a white structure, chiefly coagulated albumen; this is first formed, and afterwards the bony particles are deposited in it from red vessels.

This facility of reparation forms a very striking analogy between the white parts in man and other red-blooded animals, and the general structure of the

solids in white-blooded animals. In point of vitality, the analogy is most striking. The white parts in man, when not inflamed, (then they for a time become red parts, and have a corresponding increase of vital energy,) enjoy but a low vitality. They are scarcely, if at all, sensible; do not possess irritability; and probably, also, the circulation of the white blood through them is much slower than that of the red blood through the red parts; at least the circulation of the *white venous blood in the lymphatics* appears much less rapid than that of the red venous blood in the veins.

Hitherto *it has not been demonstrated* that the minute lymphatics open into the minute veins in man. These systems, however, have a free communication by means of the conglobate glands; and hence there cannot be much difference appreciable between the venous and arterial blood; for the circulation of the white blood being so slow, a very small portion of serum only will be lost by the arterial blood in supplying the white parts, and its loss is partly replaced by the lymph emptied into the veins. The red arteries carry fresh nutriment to the red parts, while the old particles whose removal is required, are carried off by the veins; and consequently we find that arterial blood, the vehicle of colouring matter, freshly acted on by the atmosphere, is of a bright colour, while venous blood, the medium by which the old particles are removed, is of a dark red colour, such as the colouring particles of the blood assume when for some time deprived of the influence of the air.

In fact, we must consider the veins as the proper agents for returning to the heart every thing which

has found its way into the red parts. They are not only the organs of circulation, but of absorption, for these parts; while the lymphatics bear the same relation to the white parts.

This view of the subject agrees well with the general result of the latest experiments on absorption; from which it appears that both lymphatics and veins enjoy an absorbing power, the former, probably, less extensively than the latter, their natural contents being so much more simple, and their circulation slower.

This difference of absorbing power is well marked in the veins and lymphatics which arise from the intestinal mucous membrane. They both serve for the absorption of nutritious particles into the system; and it appears from the experiments of Tiedeman and Gmelin, that the veins absorb a portion of the coloured and odorous portions of the nutriment, leaving a whitish inodorous fluid called chyme, which having been converted into chyle by the separation of the excrementitious parts, is then taken up by the lacteals.

In the commonly received theory of digestion, it has been erroneously assumed, that the chyle is the only nutriment the system derives from this process. It is, indeed, the only nutriment absorbed by the lacteals; but before the food attains to the state of a white inodorous fluid, a portion of its colouring and odorous matter must evidently have been absorbed by the veins. Therefore we must not regard the process of digestion in the stomach as conducing to the nourishment of the system, only so far as it converts

the food into chyme and chyle: for the absorption exercised by the veins during the reduction of the food to these states, must be the means of conveying much nutritious matter into the system.

The passage through the liver of all the blood returned from the intestines, is a peculiarity which shews that this blood is not mere venous blood, but contains some principles derived from the process of digestion, which require a peculiar elaboration in that organ.

Majendie has proved by experiment, that some substances which, injected into the general venous system, prove poisonous, produce no ill effects when injected into the system of the portæ. We may conclude, therefore, that the veins of the intestines take up those portions of the nutriment which would prove deleterious if passed at once into the general circulation, without being first subjected to the action of the liver; while the lacteals absorb and convey directly to the general circulation, the portions of the food left after the absorption of the former.

This mode of considering the subject *explains* the apparent similarity of the chyle, no matter what is the nature of the food; for in all cases, the process of digestion removes the most obvious physical differences, as colour, smell, before the fluid is simple enough for absorption by the lacteals.

The view already taken of the intimate connexion in all the different classes of animals, between the development of the white parts and that of the lymphatic system, is easily explained on the supposition

of the lymphatics being the veins of the white parts. In invertebrated animals, which have no red blood, it would be more rational to call the vessels conveying the white blood back to the heart, lymphatics, than veins: for it is more consistent with analogy to suppose, that in the lower animals the retained portion of the circulating system corresponds with the former, as in the superior animals the lymphatics are connected with parts, which, in their degree of vitality, most resemble the structures of the lower animals.*

In the higher classes of animals there are not only two circulating systems, one of red blood, and another of white blood, but also a twofold system of nerves, the cerebral and the ganglionic; the latter of which, in invertebrated animals, seems to perform all the nervous functions necessary to their state of existence; while these animals are also remarkable for possessing only a simple vascular system.

We find, therefore, a correspondence between the vascular system of red blood, and the nervous system of the brain and spinal marrow. They are most perfect in animals most abounding in highly aerated red blood, and decrease according to a descending scale, proportioned to the decrease of red blood, until at last we arrive at the invertebrated animals, possessing no red blood, and no brain or spinal marrow.

* In amphibious animals the valves of the lymphatics are not so strong or so close together as in the higher animals; in fishes the lymphatics do not present any glands, and have no valves, two points in which they evidently appear to approximate to the vascular system of the inferior classes.

It is not easy to determiue what place in the scale of animals we ought to assign to the fœtus of red-blooded animals, as for instance the mammalia. The fœtus in utero, is an animal evidently of an inferior order, for, as is proved by the occurrence of full grown acephalous monsters, he may exist and grow without a brain, and as his lungs are not used, he may be considered in the light of an animal without any *proper pulmonary apparatus.* These considerations seem to place the fœtus rather among the invertebrated, than among the lower orders of vertebrated animals, which was the place assigned to it by Bichat in his excellent work, Sur la Vie et la Mort. Destitute of the functions connected with the brain and spinal marrow, for the performance of which highly aerated or *arterial* blood is necessary,* the fœtus does not require the circulation of highly aerated blood, and accordingly most observers agree in denying the presence of arterial blood, properly so called, in the fœtal system. On the other hand it is very improbable that the fœtus forms an exception to the general law observed in all animals and plants, by its system not being influenced either directly or indirectly by the chemical constituents of the atmosphere. In the placenta the fœtal blood is probably aerated in a certain degree by the arterial blood of the mother, but it is evident that this mode of respiration is very incomplete when compared with direct pulmonary respiration. This low degree of respiration however, although comparatively incomplete, produces an aeration of the blood sufficient for the

* Late experiments seem however to prove, in contradiction of those of Bichat, that the functions of the brain and spinal marrow may be carried on with venous blood.

functions of fœtal life, and corresponds with the degree of respiration enjoyed by many invertebrated animals. This view of the subject inclines me not to adopt the opinion of those who maintain that there is no difference between the blood transmitted from, or returned to, the placenta, and that the blood in both the umbilical arteries and the umbilical vein is *venous;* for I conceive that the blood in the latter must be somewhat more aerated than in the former; on the other hand, I cannot subscribe to the opinion of those who maintain that *arterial blood*, properly so called, enters the fœtal system by the umbilical vein. The weight of authority is against the fact; and the functions of fœtal life do not seem to require the presence of an highly aerated blood.

If the lymphatics discharge the office of veins to the white parts, we should expect to find an ample supply of these vessels in white structures; and indeed such is the fact, for no parts so abound with lymphatics, as serous membranes, &c.

As to the want of lymphatics in the brain, it is to be observed, that this objection would apply to every use we might assign to the lymphatics, and evidently militates as much against their being absorbents as white veins. The mechanism of the cerebral circulation differs in so many remarkable particulars from the circulation of other parts, that we need not be surprised at finding an anomaly with regard to the lymphatics also.

As to the functions of the lymphatic glands, I confess myself unable to give any satisfactory explanation. It has been proved by *Fohman* and *Lauth*, that

the opinion of the elder Meckel was correct so far as regards the anastamosis which takes place within the conglobate glands, between the veins and lymphatics. *Dutrochet* has assigned to them the office of assisting the circulation of the lymph; and *Fohman* has conjectured that they serve to aerate the lymph, by bringing it into contact with the small arterial ramifications within their substance; but the reasons advanced by these distinguished physiologists, do not appear to me satisfactory.

As the circulation of white parts differs from that of red, so do their diseases. Time will not permit me to enter on this important subject at present, concerning which *Broussais* has already made some well-founded observations, we may remark, however, that inflammation of white parts observes a peculiar character, and seems to have little influence on the sanguiferous system of red blood, unless it becomes so violent that red blood finds its way into their vessels. When this takes place we find the albuminous and serous products of white, exchanged for the *fibrinous* products of red inflammation. As to the sensibility of these parts it is but little as long as white blood circulates in their structures, but when they are inflamed to the point of admitting red blood, their sensibility becomes exquisite.

To conclude these remarks hastily thrown together for the purpose of eliciting further inquiry on the subject, it is necessary to observe that *Majendie* has approximated to the view of the functions of the lymphatic system which I have given. He states it as his opinion, that a portion of the serum of the blood is

returned to the heart by the lymphatics; he does not, however, even hint why it should be so, nor does he seem to have had any notion of its being the venous blood of the white parts of the body.

NOTE.—Dr. Bostock (Elementary System of Physiology, vol. 1. p. 199,) says, that "in some cases where he had an opportunity of examining the "fœtus immediately after its extraction from the uterus, the different "colours of the blood in the funis appeared quite obvious."

In the cases observed by Dr. Bostock it is evident that many minutes must have elapsed between the first exposure of the funis to the air and his examination of it. This circumstance alone is sufficient to account for the difference of colour in the blood of the umbilical arteries and vein. *Majendie* has shewn (Journal de Physiologie, tom. 1. p. 17,) that the blood contained within the jugular vein in young animals, very soon assumes the arterial colour, when the vein is exposed to the air, and the course of the blood in it retarded by pressure. When the abdomen of a living animal is opened, he says that a similar change of colour may be observed in the blood of the mesenteric veins, in the course of a few seconds. As the coats of the umbilical vein are thinner, and consequently more permeable by the air, than those of the umbilical arteries, a very short time will be sufficient to make an obvious difference in the colour of their contained blood.

FINIS.